Minutes of the Femtosource Lattice Meeting in 2002

Ina Reichel

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Meeting on May 14th 2002

Minutes taker Ina Reichel

Those present I. Reichel, A. Wolski, A. Zholents

Absent(excused) W. Wan, J. Corlett

Date May 15th 2002

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J. Corlett
I. Reichel
D. Robin
W. Wan
A. Wolski
A. Zholents

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1 Database of lattice files (I. Reichel)

Problem: We want to use either RCS or CVS but we need it to run at least on UNIX and Windows.

CVS is available on UNIX, RCS probably, too. Andy actually uses CVS on a Windows-PC for files located on a UNIX machine at DESY. So it should be possible to use CVS for the project.

Ina will ask Russ Wells if we can use disk-space on the web-server of the project to store the files.

Ina will try to get a system set up ASAP in order to facilitate sharing the lattice files.

2 Design of the first bunch compressor (I. Reichel)

Ina presented a preliminary design based on two Double Bend Achromats (DBA). Each achromat bends the beam 45°, i.e. each bend by 22.5°. The bending radius is about 50 cm.

The bending radius should be larger to minimize effects from coherent synchrotron radiation. Sasha suggests to use at least 1.5 m (corresponding to 3 kGauss). I order to keep within space requirements this means using less than 45° bending radius.

We do not want to do the compression only with the DBAs as this leaves us no flexibility on the amount of compression. In order to avoid having a separate compressor Ina will design a line using Triple Bend Achromats (TBA) instead of the DBAs. This should make the lattice more flexible.

3 Analysis of the second bunch compressor (W. Wan)

Moved to next meeting due to absence of speaker.

4 Differences between MAD and COSY (W. Wan)

Moved to next meeting due to absence of speaker.

Meeting on May 21st 2002

Minutes taker Ina Reichel

Those present I. Reichel, W. Wan, A. Zholents

Date May 22nd 2002

Distribution
J. Corlett
I. Reichel
D. Robin
W. Wan
A. Wolski
A. Zholents

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1 Database of lattice files (I. Reichel)

We can use diskspace on the server of the project. They have a software called "Intralink" that is somewhat similar to CVS. We can use that. It runs on PCs and UNIX. Ina is working on getting everything set up there.

2 Design of the first bunch compressor (I. Reichel)

Ina presented a preliminary design based on two Triple Bend Achromats (TBA). Each achromat bends the beam 30°, i.e. 10° per bending magnet. The bending radius is about 1.7 m. The current lattice is shown in Fig 1. The overall R_{56} with this lattice is only 0.02, i.e. too small. The beamline is currently more than 10 m long and about 2.5 m wide. This size should not be a problem according to Sasha.

It needs to be found out why MAD gives positive dispersion in both "arcs" although they bend in opposite directions. This might change R_{56}.

In order to get the right R_{56} one can either change the strengths of the quads making the achromat not achromatic anymore or one can install a little compressor somewhere. Ina will study both options. Without the compressor the best solution might be to match one TBA with sensible boundary conditions for β-functions and dispersion and half the

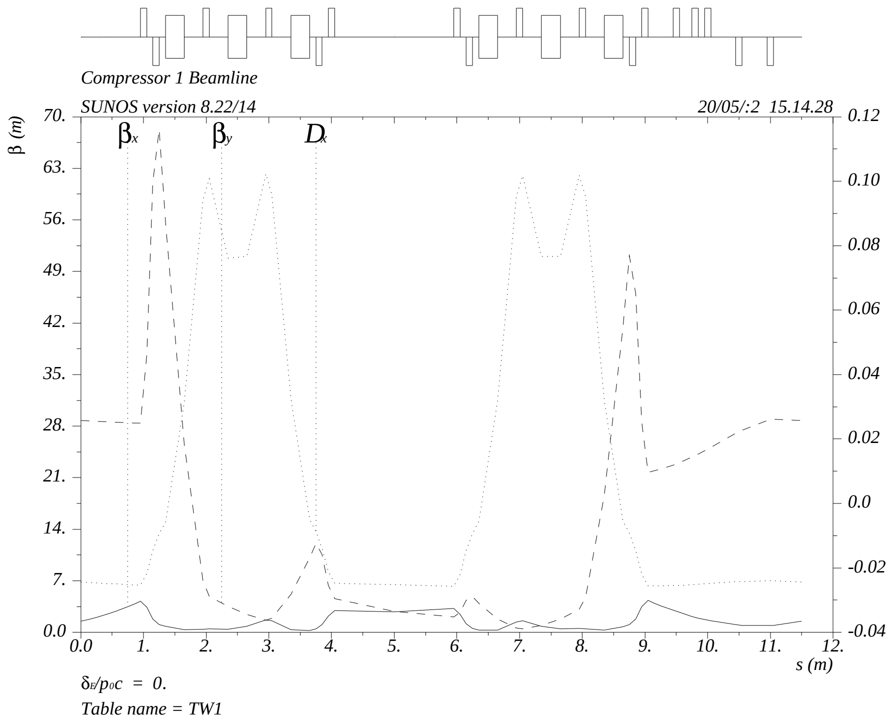

Figure 1: Preliminary lattice for the first beamline without a dedicated compressor based on two Triple Bend Achromats.

required R_{56} and then just double that and add a few quads to match to the rest of the world.

3 Analysis of the second bunch compressor (W. Wan)

Weishi presented a solution with sextupoles and some tracking results for Arc 0 to show the influence of the sextupoles. Figure 2 shows the longitudinal plane with the sextupoles. Figures 3 and 4 show that in the transverse planes the sextupoles do not significantly change the beam profile compared to the linear lattice (assuming no errors in both cases).

4 Differences between MAD and COSY (W. Wan)

For drifts MAD and COSY agree to second order, but there is a difference for bending magnets (the vertical plane is treated differently). Weishi has contacted John Jowett and Frank Schmidt at CERN but has not yet heard back from them.

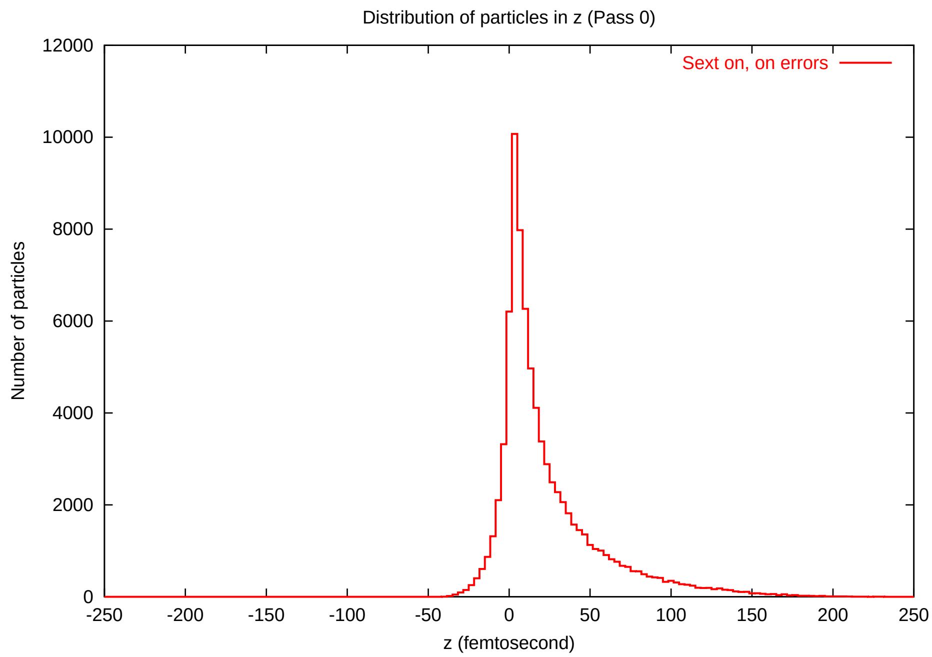

Figure 2: Tracking results for Arc 0 for the longitudinal plane with sextupoles on.

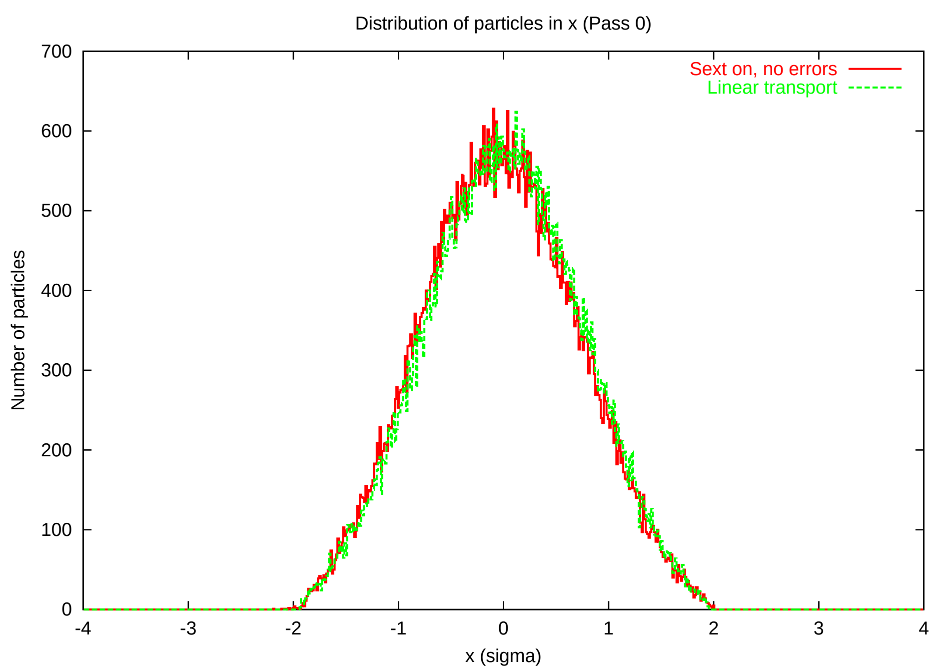

Figure 3: Tracking results for Arc 0 for the horizontal plane with the sextupoles on and with a linear model.

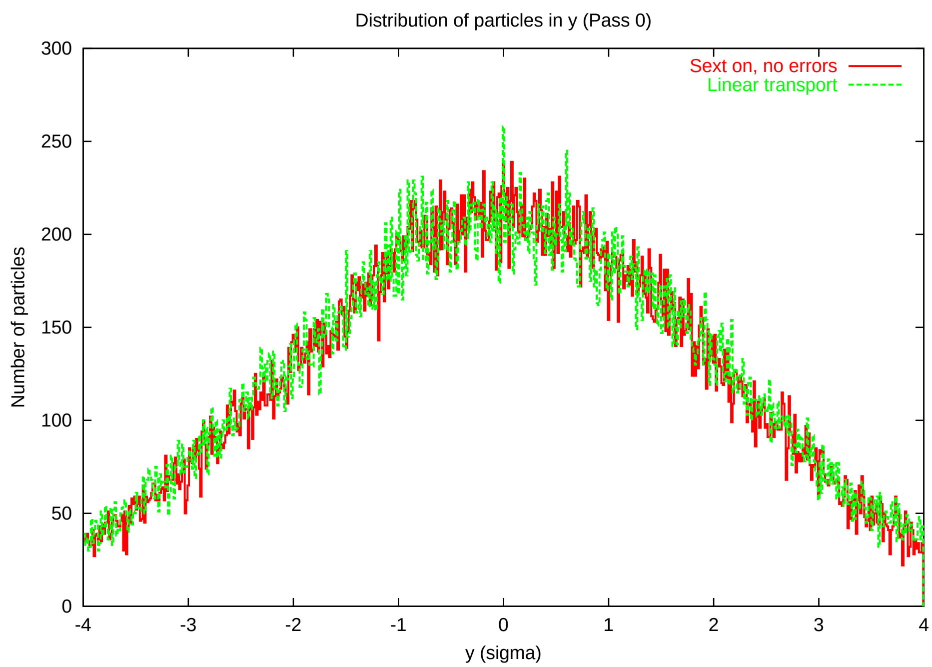

Figure 4: Tracking results for Arc 0 for the vertical plane with the sextupoles on and with a linear model.

Meeting on June 25th 2002

Minutes taker Ina Reichel

Those present J. Corlett, I. Reichel, W. Wan, A. Zholents

Absent(excused) A. Wolski

Date June 28th 2002

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J. Corlett
I. Reichel
D. Robin
W. Wan
A. Wolski
A. Zholents

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1 Database of lattice files (I. Reichel)

It turns out we will probably not have to use "Intralink". Current plan is to use CVS and to email the newest version once per week to a person who will put them into "Intralink" (this will be done by Ina by hand to start with but later a batch job will do that). Currently we think once a week seems reasonable but that may change.

Ina will try to get everything set up ASAP.

2 News from EPAC (J. Corlett, I. Reichel)

There was interest in the posters on our project. John gave a short summary on the status of similar projects in other labs.

3 Update on a design of the first bunch compressor (I. Reichel)

Ina found the bug why the dispersion had the same sign in both bending sections. The bending angles were actually the same due to a COPY&PASTE error.

With the current constraints (each bending section symmetric and both sections the same except for the bending angle) it is not possible to get a large enough R_{56}. So Ina is looking into putting a small chicane in. The chicane should go as close as possible to the end of the line to keep the bunch long as long as possible. However one cannot put it in the straight after the last bending magnet as this would interfere with an energy recovery upgrade. Ina is currently trying to put it in between the two bending sections. If that fails due to lack of space it will have to go right after the gun before the first bending section.

Weishi suggested to loosen the constraints on the symmetry in order to get the required R_{56}. Ina will try that before further pursuing the extra chicane.

4 "Strange seed" for Pass 3 (W. Wan)

Weishi is tracking ring 3 (using COSY) with errors and tries to correct the orbit in order to preserve the vertical emittance. Figure 5 shows tracking results before orbit correction, Fig. 6 shoes the same after orbit correction. One seed sticks out which still has a large beam size. Weishi assumes it is due to coupling for which he does not correct yet. After using a different setting of the sextupole magnets, this seed also has a beam size comparable to the other seeds (see Fig. 7).

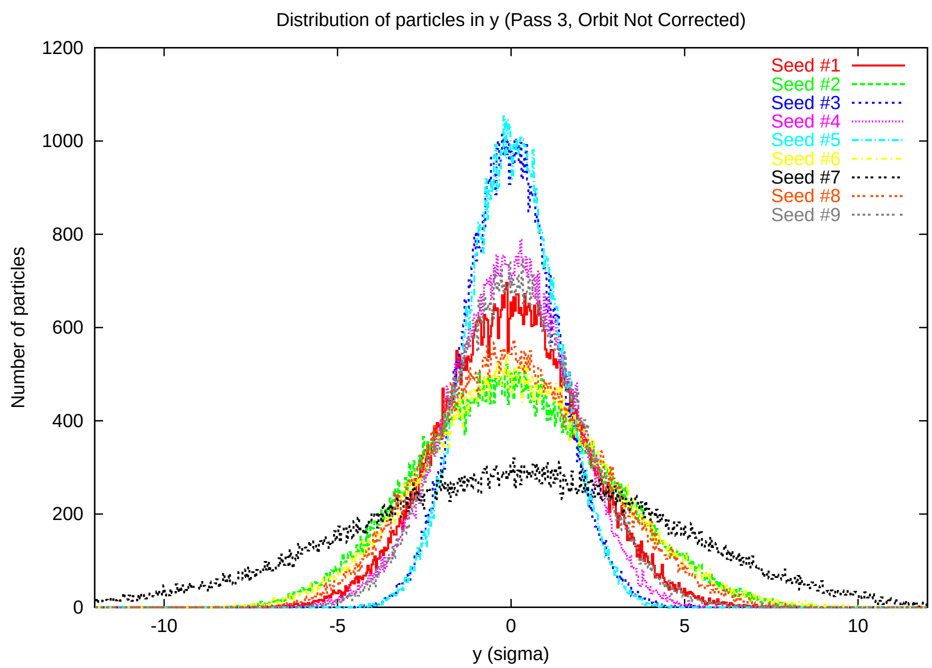

Figure 5: Tracking results (vertical particle distribution) for ring 3 before orbit correction.

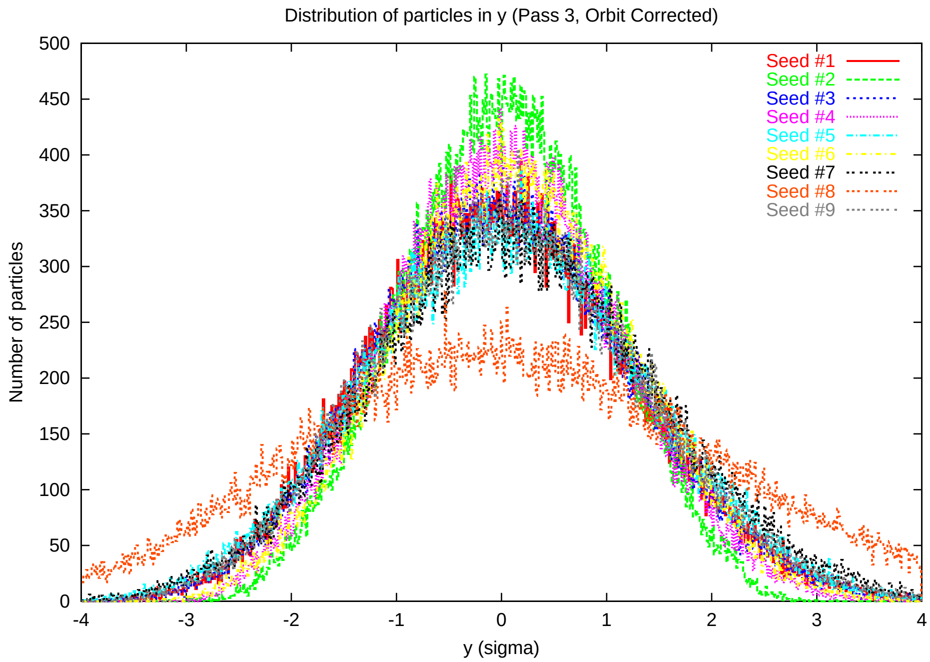

Figure 6: Tracking results (vertical particle distribution) for ring 3 after orbit correction.

Currently perfect BPMs are assumed for these studies. The results might get worse if errors on the BPMs are included. The errors are listed in Tab. 1.

Table 1: Errors used in the tracking studies.

magnet strength	$1 \cdot 10^{-3}$
magnet tilt	$0.2\,\mathrm{mrad}$
transverse misalignment	$150\,\mu\mathrm{m}$
longitudinal misalignment	$1\,\mathrm{mm}$
B_3/B_1 at 3 cm	$1 \cdot 10^{-4}$
B_3/B_2 at 5 cm	$1 \cdot 10^{-4}$

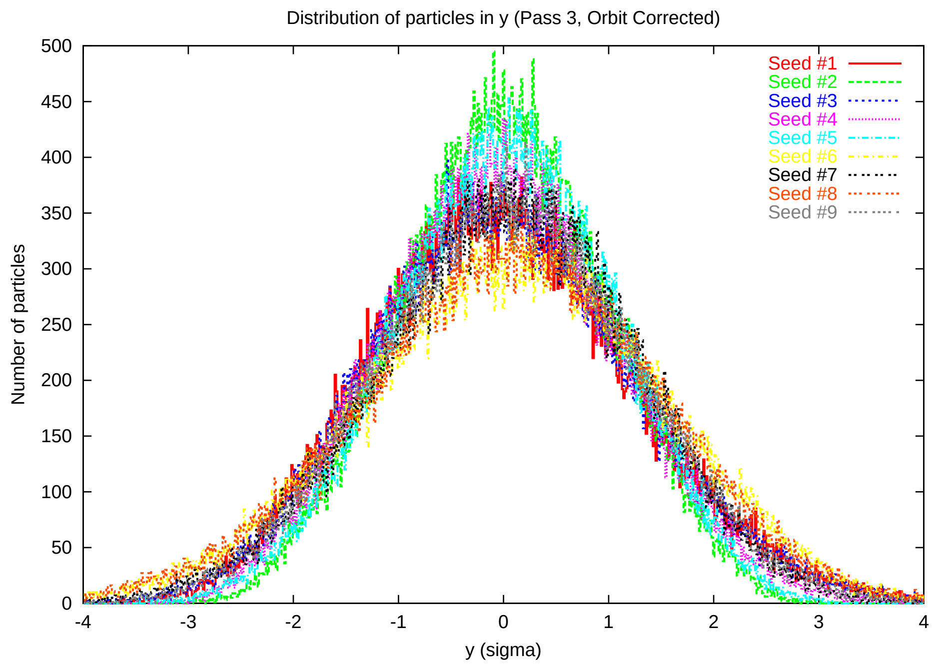

Figure 7: Tracking results (vertical particle distribution) for ring 3 after orbit correction using different settings for the sextupoles.

Meeting on July 2nd 2002

Minutes taker Ina Reichel

Those present J. Corlett, I. Reichel, W. Wan, A. Wolski

Absent(excused) A. Zholents

Date July 19th 2002

Distribution

J. Corlett
I. Reichel
D. Robin
W. Wan
A. Wolski
A. Zholents

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1 Update on a design of the first bunch compressor (I. Reichel)

With the current boundary conditions (bending angle larger than 1.5 m for CSR and 30° total bending in each direction) and the available real estate it is at least very difficult to get the required R_{56} (Ina's current version still has a too small R_{56} and is likely to be already too wide to fit into the available space). One possibility could be to use the space between the pre-linac and the return line instead of between pre-linac and main linac or to make the arc between pre-linac and linac wider to have more space.

Other possibilities are using an alpha-magnet instead of the beamline or using less bending angle in which case it is even harder to get the required R_{56} without a chicane but on the other hand one has more space to put a chicane.

Ina will either come up with a beamline without a chicane or the conclusion that a chicane is necessary. She will also look into the feasibility of an alpha-magnet (might be problematic due to CSR or shielding or space requirements).

2 Details on particle tracking and sensitivity of errors (W. Wan)

The large vertical beam size before orbit correction (see left of Fig. 10 and Fig. 11) is probably due to coupling caused by large (several mm) offsets in the sextupoles but Weishi has not yet looked at the vertical dispersion.

The one "bad" seed (see Fig. 10) is due to a large orbit offset in one particular sextupole magnet. If this magnet is simply switched off (solution 2), the vertical emittance (after orbit correction with the new sextupole setting) is comparable to the one for the other seeds (see Fig. 11). For reasons not completely understood even very small offsets in this one sextupole create a large vertical emittance. One suspicion is that this is due to coupling as the phase advance from this sextupole to the next is about π. Weishi will look into it as one seed out of nine is not that small a probability for the real machine that one gets a "bad" seed.

The z-distribution after orbit correction is not influenced much by having this sextupole on (solution 1) or off (solution 2). However it is significantly larger if all sextupoles are off.

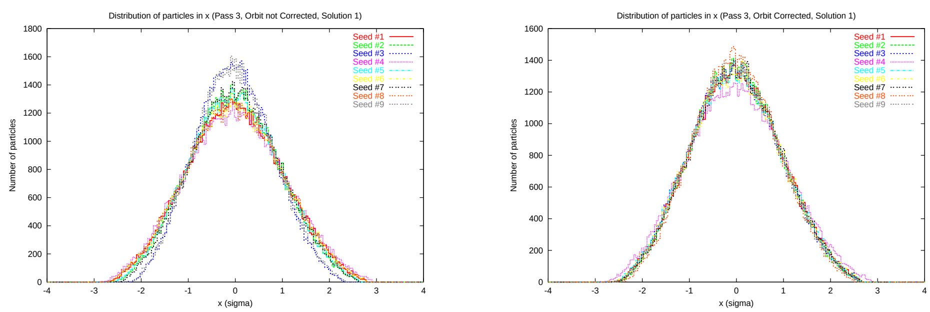

Figure 8: Tracking results: Particle distribution in x before (left) and after (right) orbit correction for sextupole solution 1.

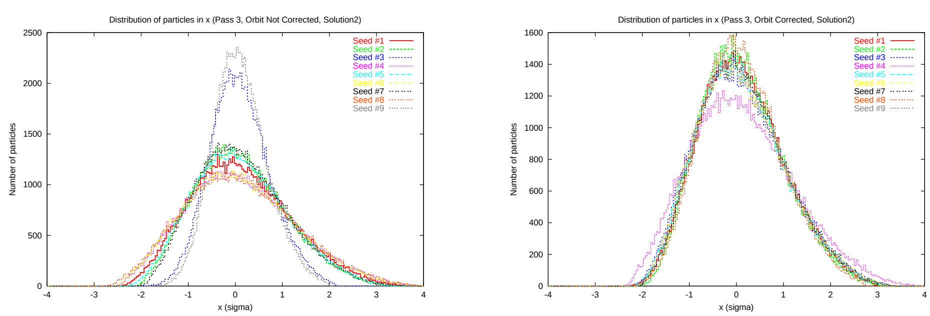

Figure 9: Tracking results: Particle distribution in x before (left) and after (right) orbit correction for sextupole solution 2.

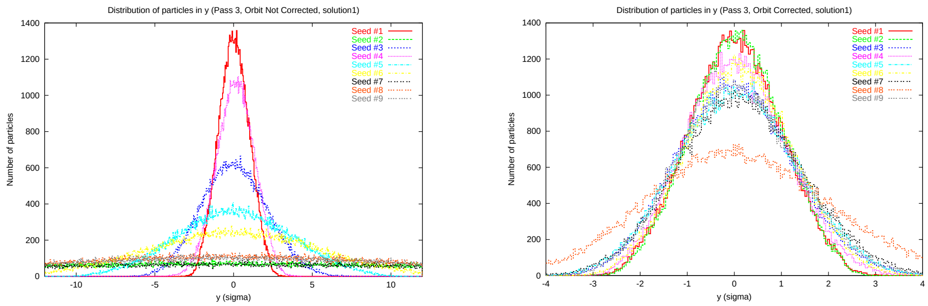

Figure 10: Tracking results: Particle distribution in y before (left) and after (right) orbit correction for sextupole solution 1.

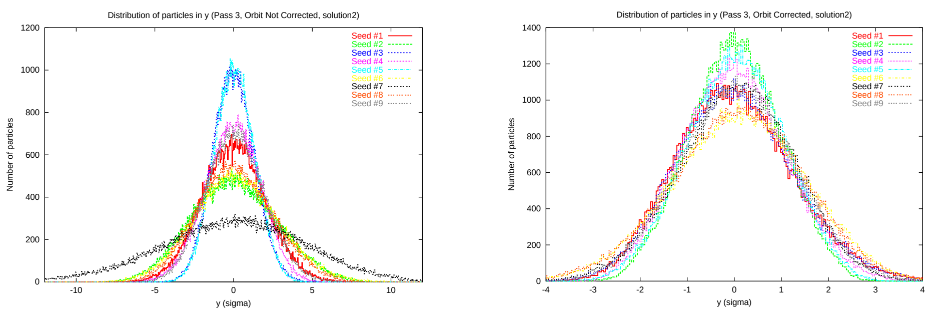

Figure 11: Tracking results: Particle distribution in y before (left) and after (right) orbit correction for sextupole solution 2.

3 Database of lattice files (I. Reichel)

We will not have to use “Intralink” after all. Currently we are looking for disk space to store the files for CVS. John suggested to put them on BC1. Ina will contact Vladimir Eberman to find out if we can use disk space there and to get everything set up if possible.

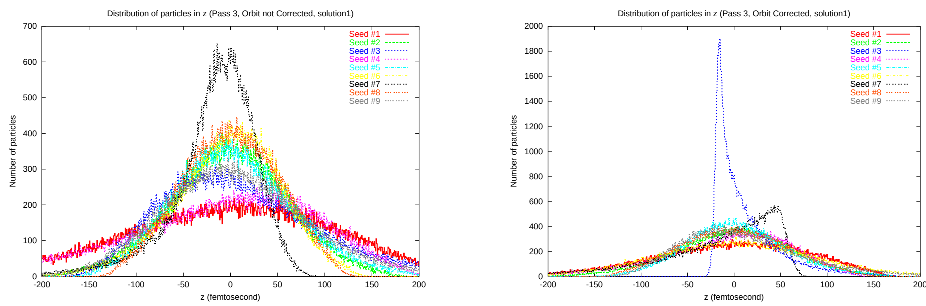

Figure 12: Tracking results: Particle distribution in z before (left) and after (right) orbit correction for sextupole solution 1.

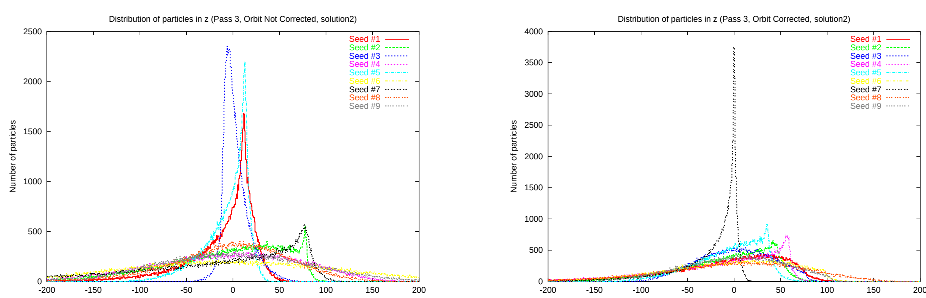

Figure 13: Tracking results: Particle distribution in z before (left) and after (right) orbit correction for sextupole solution 2.

Meeting on July 9th 2002

Minutes taker Ina Reichel

Those present I. Reichel, S. de Santis, W. Wan, A. Wolski, A. Zholents

Date July 19 2002

Distribution

J. Corlett
I. Reichel
D. Robin
S. de Santis
W. Wan
A. Wolski
A. Zholents

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1 Tracking results using MERLIN (A. Wolski)

Andy presented first tracking results using MERLIN. He has tracked just the linac and also the whole machine. The short-range wakefields are calculated using an equation from the TESLA design report. The results for no charge show a correlation between y and z. As it shows up in the zero charge tracking it cannot be due to wake effects. Weishi thinks it is due to chromatic effects but it could also be due to RF focusing.

Andy uses the same model for the cavities that is used for TESLA so it should be the right model and include higher order effects.

Currently the RF is phased to the bunch but Andy is working on a version which keeps track of the timing for multiple passes.

Andy has not yet compared his results with Stefanos calculations.

2 Update on a design of the first bunch compressor (I. Reichel)

Ina is still trying to find a lattice without a dedicated compressor. She has some lattices which have the required R_{56} but they always have a large dispersion prime at the end of the beamline due to the required asymmetry. Ina will try for two more days if she can find a solution. After that she will look into designing a beamline with a dedicated compressor.

3 Error studies (W. Wan)

No new results yet.

4 News from Sardignia workshop (A. Zholents)

Sasha reported on the Meeting on high brightness electron beams which took place in Sardignia the previous week.

As all other people currently working on compressors simulate coherent synchrotron radiation effects we should better do so, too, even if we think it will be no problem as reviewers might ask after having seen simulations from other machines. There are several codes available which differ in which physics effects are included, so we might have to use more than one.

The following codes seem to be most widely used:

ELEGANT by Michael Borland from ANL. This code is widely used and seems to be well documented.

TRAFFIC4 by Andreas Kabel from SLAC. This code has more physics effects included than ELEGANT.

TREDI Sasha is not sure where this code is from. He thinks it is probably from Frascati. This code seems to be more obscure than the other two codes.

Meeting on July 16th 2002

Minutes taker Ina Reichel

Those present J. Corlett, I. Reichel, S. de Santis, W. Wan, A. Wolski

Absent(excused) A. Zholents

Date July 19th 2002

Distribution
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1 Tracking results from MERLIN (A. Wolski)

The tracking was done with a completely flat bunch and includes the full RF focusing which is not in the theoretical model. The RF focusing is expected to reduce the bunch shape distortion, so this is consistent with the results. The comparison indicates that the tracking code with the wake fields is working correctly. Figure 14 shows tracking results (dots) and analytical calculations (line).

As Andy sees strong effects from the fringe fields of the cavities there was a lengthy discussion if this effect is also included in MAD.

The next step is to confirm the lattice, and study the effects of misalignments in the main linac on the final bunch shape.

2 Update on a design of the first bunch compressor (I. Reichel)

Ina got a detailed drawing from Russ Wells to show the available space. The horizontal offset of the beamline has to be 3.19 m or less.

She has tried some more lattices in order to achieve the required R_{56} but they all fail for one or more of the following reasons:

- large dispersion prime at the end of the beamline

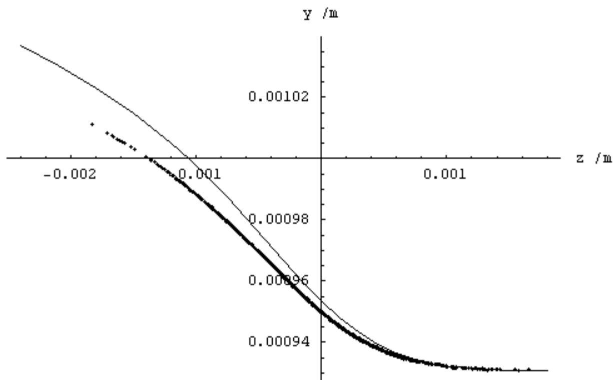

Figure 14: Comparison between tracking results from MERLIN (dots) and analytical calculations (line).

- too small R_{56}
- need much more space than is available

Ina has found a solution using a dedicted compressor. The compressor itself is approximately 6 m long and uses four 60 cm long bending magnets which have a bending angle of 0.4 rad. The horizontal offset of the beamline is done using two double bend achromats (one for each direction). The solution needs a bit more fine-tuning as not all boundary conditions are matched exactly (they are close enough so that it should not be too difficult). The offset in the compressor is about 1 m. The lattice is shown in Fig. 15.

As this solution does not allow to adjust R_{56} much, Weishi suggested looking into using big 45° bending magnets and a very wide beam pipe. Ina will look at that to see what dimensions are necessary.

As soon as a final lattice is available Ina will study effects of coherent synchrotron radiation using ELEGANT and TRAFFIC4.

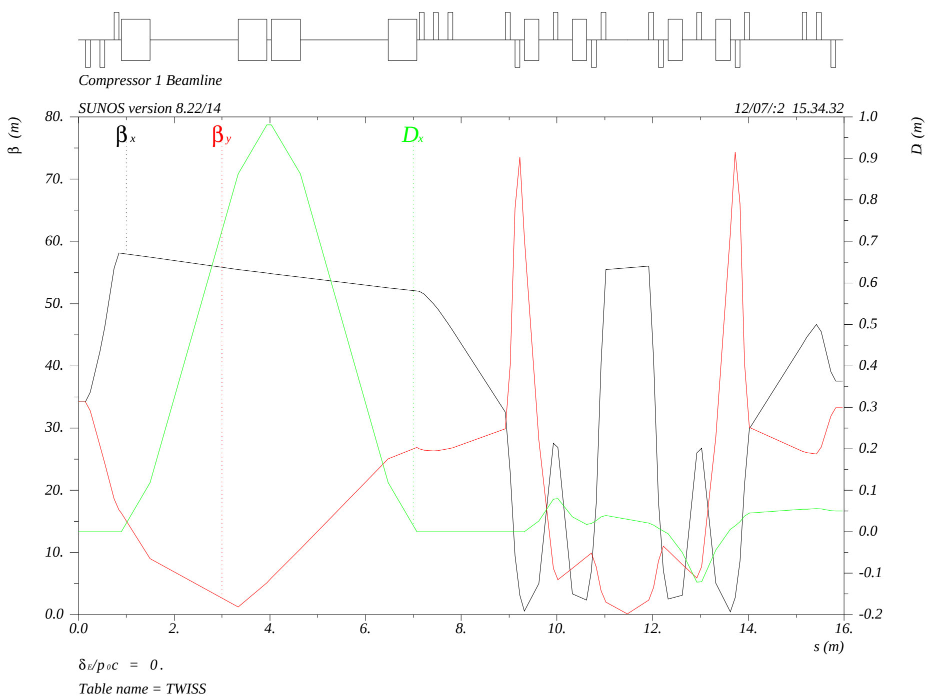

Figure 15: Preliminary lattice for the first compressor using a dedicated compressor and two double bend achromats.

Meeting on July 23rd 2002

Minutes taker Ina Reichel

Those present I. Reichel, S. de Santis, W. Wan, A. Wolski

Absent(excused) J. Corlett, A. Zholents

Date July 23rd 2002

Distribution
J. Corlett
I. Reichel
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A. Zholents

Overview of topics

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3 **Update on MERLIN tracking (A. Wolski)** **20**

1 Update on the first bunch compressor (I. Reichel)

For some reason there is always some residual dispersion (about 5 cm) at the end of the line. It could be due to dispersion prime not being exactly zero (required as of the boundary conditions). Weishi and Andy had some suggestions what to try to get it smaller.

2 Update on lattice studies (W. Wan)

Etienne Forrest left a new version of his code with Weishi. Weishi has not tried it yet.

3 Update on MERLIN tracking (A. Wolski)

No new tracking results but some more information on the matrix element for standing wave cavities in MAD compared to other codes. The element R_{21} is zero in MAD however in the literature for standing wave cavities this element usually is non-zero (although small). This could account for differences between different codes.

Meeting on July 30th 2002

Minutes taker Ina Reichel

Those present J. Corlett, I. Reichel, A. Wolski, A. Zholents

Date July 30 2002

Distribution

J. Corlett
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1 Update on a design of the first bunch compressor (I. Reichel)

Ina now has a design for the compressor line which has zero dispersion at the end (see Fig. 16). Sasha suggested to use a simpler line instead of the DBAs. He suggests to use just one dipole per bending sectionand then put five quadrupoles in bewteen which can all have the same strength (the pattern would be `BFDFDFB`). Ina will look at that.

Ina will start tracking this lattice using TraFiC4. If there are no problems with CSR she will try to rematch the lattice using a smaller bending radius which should make the beamline more compact.

2 Cavity tracking differences between different codes (A. Wolski)

The current conclusion is that MAD uses the correct fringe fields but does not include the focussing due to the body of the cavity. In our case this effect is very small and therefore should be negligible.

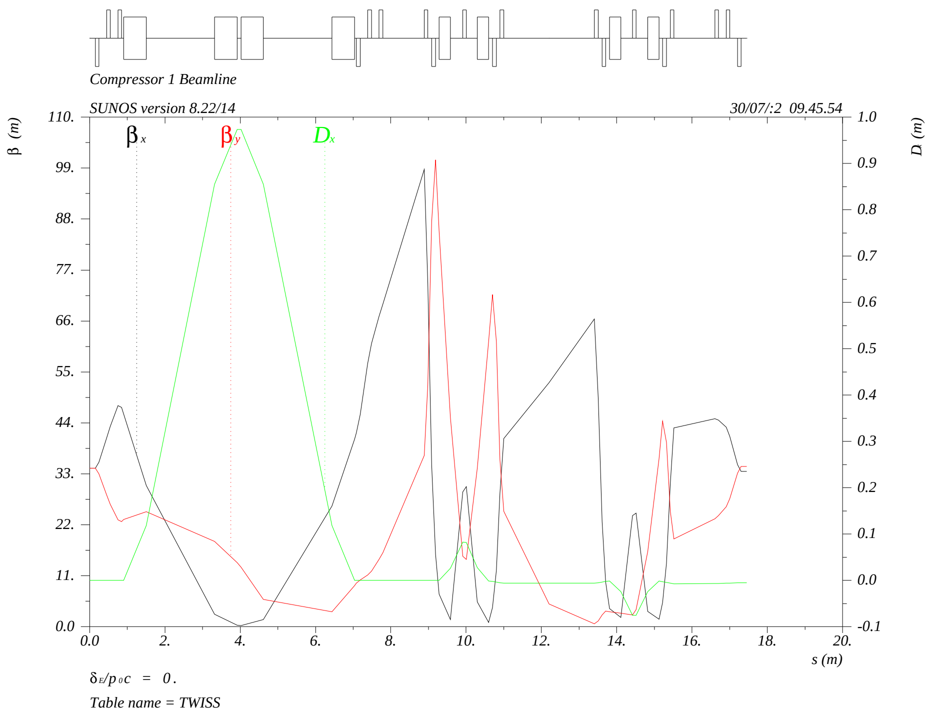

Figure 16: Lattice for the first compressor using a dedicated compressor and two DBAs.

Meeting on August 6th 2002

Minutes taker Ina Reichel

Those present J. Corlett, I. Reichel, A. Wolski, W. Wan

Absent(excused) A. Zholents

Date August 7 2002

Distribution

J. Corlett
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1 Update on a design of the first bunch compressor (I. Reichel, W. Wan)

Using Sasha's suggestion from last week Ina has an almost finished design. The beta-functions are not yet exactly matched, but it looks good overall.

Ina got TraFiC4 to run and produce reasonable looking output using an example file provided by A. Kabel. She'll set up a meeting with A. Kabel and some people from the femtosource to clarify the input parameters needed.

Weishi recently played around with the compressor/beamline, too, and found a solution without a dedicated compressor with a large tuning range for R_{56} (0.1 m to 1.0 m).

2 Lattice database and CVS (I. Reichel)

Ina installed a test directory and is currently waiting for Nancy Lewis to try to check out files to see if it works. As soon as everything works everybody will get en email with instructions.

There was a discussion about who actually has a current version of the lattice files for Ina to put in there once everything works. It looks like both Andy and Weishi have an up-to-date version (as Andy did not change anything in the version he got from Weishi).

3 More cross-checks between MERLIN and Stefano's analytical results (A. Wolski)

Andy tracked just the cavities in MERLIN for all four passes. The results agree well with Stefano's calculations, so it looks like MERLIN gets the wakefields right.

Andy also tracked the whole machine from the entrance of the main linac to the end of the undulator farm with and without the sextupoles and it looks like the effect is small. The sextupoles remove the tail from the longitudinal distribution (see Fig. 17) but they slightly distort the horizontal phase space (see Fig. 18). Tracking included transverse wakefields only in the main linac, no machine errors or bunch offsets or distortions.

There was some discussion if the higher order components of the dipoles in MERLIN are actually treated correctly and if in case they are not, the sextupoles should actually make it worse.

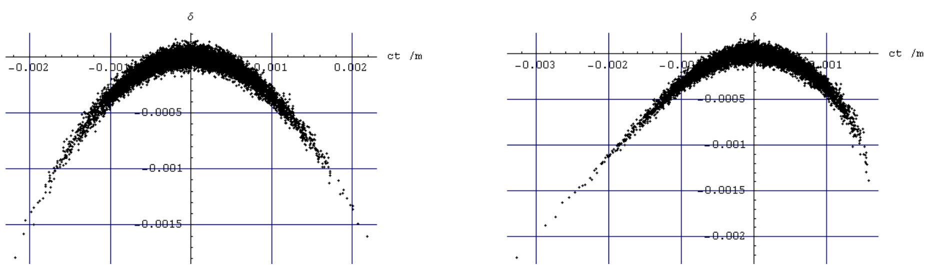

Figure 17: Tracking results in the longitudinal plane from MERLIN from start of main linac to end of undulator farm with (left) and without sextupoles (right).

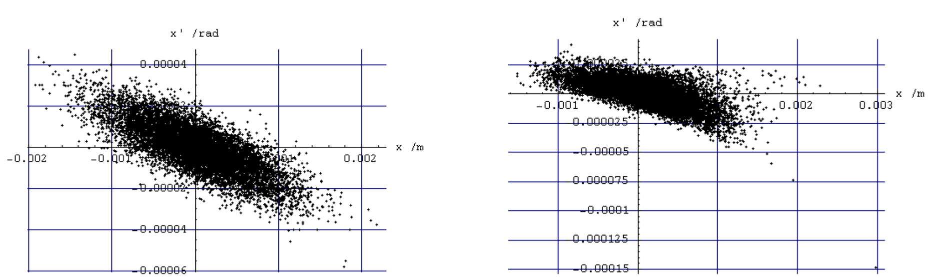

Figure 18: Tracking results from MERLIN for the horizontal plane from start of main linac to end of undulator farm with (left) and without sextupoles (right).

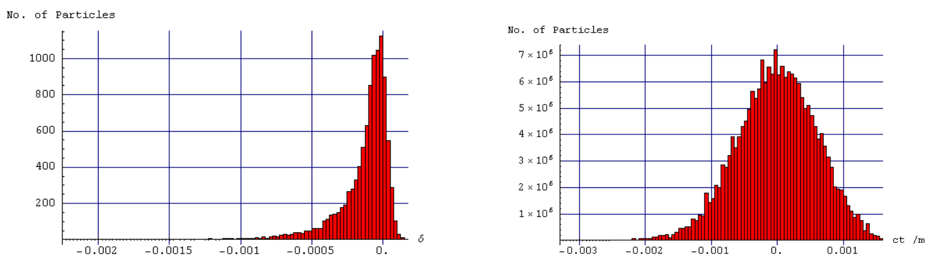

Figure 19: Tracking results from MERLIN from start of main linac to end of undulator farm without sextupoles: Energy spread (left) and bunch length histograms. With sextupoles on the histograms are only slightly changed.

Meeting on August 13th 2002

Minutes taker Ina Reichel

Those present J. Corlett, I. Reichel, A. Wolski, W. Wan, A. Zholents

Date August 15 2002

Distribution

J. Corlett
I. Reichel
D. Robin
S. de Santis
W. Wan
A. Wolski
A. Zholents

Overview of topics

1 Update on a design of the first bunch compressor (I. Reichel, W. Wan) 26

2 Lattice database and CVS (I. Reichel) 27

3 Newest tracking results from MERLIN (A. Wolski) 27

1 Update on a design of the first bunch compressor (I. Reichel, W. Wan)

Ina now has a finished version using a dedicated compressor (see Fig. 20)..

Weishi has worked some more on his solution but cannot get rid of the small β-functions (both are small at the same place). Due to the low beam energy the small β-functions could lead to problems due to space charge effects. It is not easy to get the β-functions larger, as the required R_{56} is large and therefore the quadrupoles need to be fairly strong, i.e. have short focal lengths.

Sasha suggested using a larger energy spread and reducing R_{56} which would make the design of the first compressor significantly easier. His idea is to increase the energy spread by about a factor of five but decrease R_{56} only by a factor of two or three and then use the residual correlation in the second compressor (after the pre-linac). No one immediately found an obvious reason why that should not work but we will have to look at the rf-focusing in the pre-linac. Andy will track this though the pre-linac to see if there are any adverse effects.

Both lattices (Ina's and Weishi's) should be checked for space charge effects as they are a problem for the beamline just before the compressor which had not been expected.

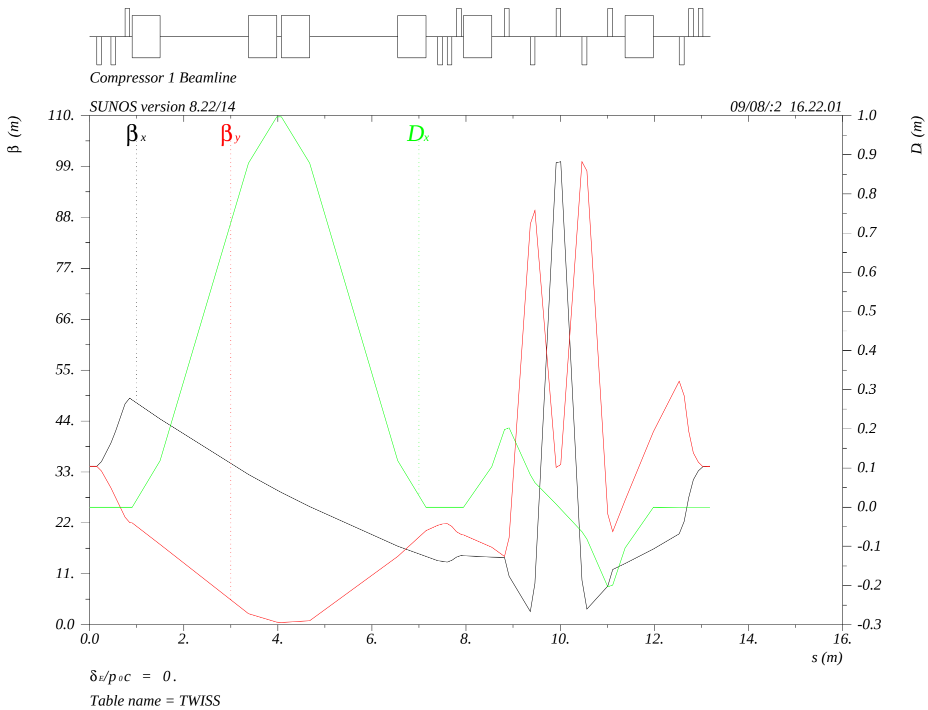

Figure 20: Lattice for the first compressor using a dedicated compressor.

2 Lattice database and CVS (I. Reichel)

The test directory is ready and Ina emailed everyone instructions. So far no one has tried it.

3 Newest tracking results from MERLIN (A. Wolski)

Andy tracked a bunch trough the whole machine for the first time using nominal parameters. The simulation includes misalignment of the rf cavities but no misalignment of other elements and no orbit correction. The sextupoles are ON. Figure 21 shows the dependence of the vertical emittance on the misalignment of the cavities with and without wake fields. No effect of the wake fields is visible.

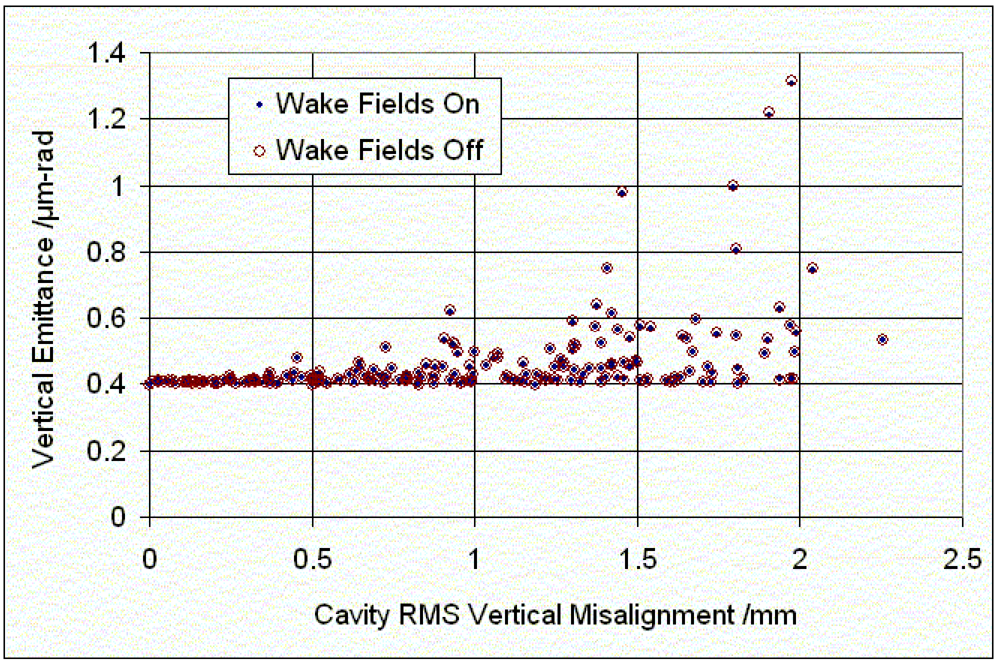

Figure 21: Tracking results from MERLIN for the whole machine with sextupoles ON including misalignment of the rf cavities with and without wake fields.

Meeting on August 20th 2002

Minutes taker Ina Reichel

Those present J. Corlett, M. Placidi, I. Reichel, A. Wolski, W. Wan, A. Zholents

Date August 26 2002

Distribution
J. Corlett
M. Placidi
I. Reichel
D. Robin
S. de Santis
W. Wan
A. Wolski
A. Zholents

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5 Tracking through photon production section **32**

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1 Relaxing R_{56} in the first compressor (A. Zholents)

After last weeks discussion, Sasha looked at the longitudinal phase space for different scenarios of changing R_{56} and the correlated energy spread in the first compressor (see also the attached note at page 34ff):

- $R_{56} = 0.72\,\mathrm{m}$: This is the "old" number. It uses a correlated energy spread of ± 20 keV and a bunch length of ± 10 ps. The second compressor in this case uses $R_{56} = 0.93\,\mathrm{m}$.
- $R_{56} = 0.18\,\mathrm{m}$: With the linearizer at 1.4 MeV and a phase angle of $-15°$ from the crest (angle was optimized) one still gets the desired bunch length of ± 5 ps but keeps a correlated energy spread which is distorted after passing the pre-linac.With the second linearizer at 12 MeV and a phase angle of $-10°$ one then

uses $R_{56} = 0.55\,\mathrm{m}$ in the second compressor (see Fig. 22). With this, the final bunch looks very similar to the "old" design. The bunch is slightly shorter but has a slightly larger energy spread. Both compressors also need a non-zero R_{566}.

- $R_{56} = 0\,\mathrm{m}$ with dogleg: As the second compressor contains an arc bending 180°, it is fairly easy to achieve a large R_{56}. Therefore Sasha also looked at doing away with the first compressor and doing all the compression from 20 ps to 2 ps in the second compressor. This would also eliminate the first linearizer. The second (and now only) linearizer needs to run at 13.5 MeV and -3°. In the second compressor an R_{56} of 1.86 m but no R_{566} is needed. The results on the final bunch length and energy spread are comparable to the other scenarios. This option has the advantage of having potentially less problems with coherent synchrotron radiation and space charge as the bunch length is only shortened at an energy of 120 MeV instead of at 10 MeV.

  In order to use this solution one needs a very large R_{56} in the second compressor. Sasha rematched the lattice with the larger R_{56} and found a solution. The β-functions are not that different from the "old" version but the dispersion is significantly larger in the arc (see Fig. 22).

  In this case the dogleg part is fairly simple. Sasha has a basic lattice which is not yet matched to the boundary conditions (see Fig. 23).

- $R_{56} = 0\,\mathrm{m}$ without dogleg: As it is not clear if we really will ever use energy recovery, in case of doing away with the first compressor one could also think about doing away with the dogleg, too, as its sole reason for being is now energy recovery. This might allow putting the flat beam adaptor in between the linearizer and the arc instead of before the pre-linac, i.e. do the flat beam conversion at a higher energy which might solve some of the space charge problems.

For all cases of smaller (or zero) R_{56} the transverse effects need to be studied. Andy had a short look at it but found out that MERLIN does not take the energy spread into account correctly. He is working on fixing that and hopes to have first results by next week.

2 Update on a design of the first bunch compressor (W. Wan)

Weishi now has a solution with reasonable β-functions (see Fig. 24). R_{56} is tunable over a large range.

3 TraFiC4 (I. Reichel)

Ina put the compressor part of the first compressor beamline in (but not the rest of the beamline yet). So far it seems to work.

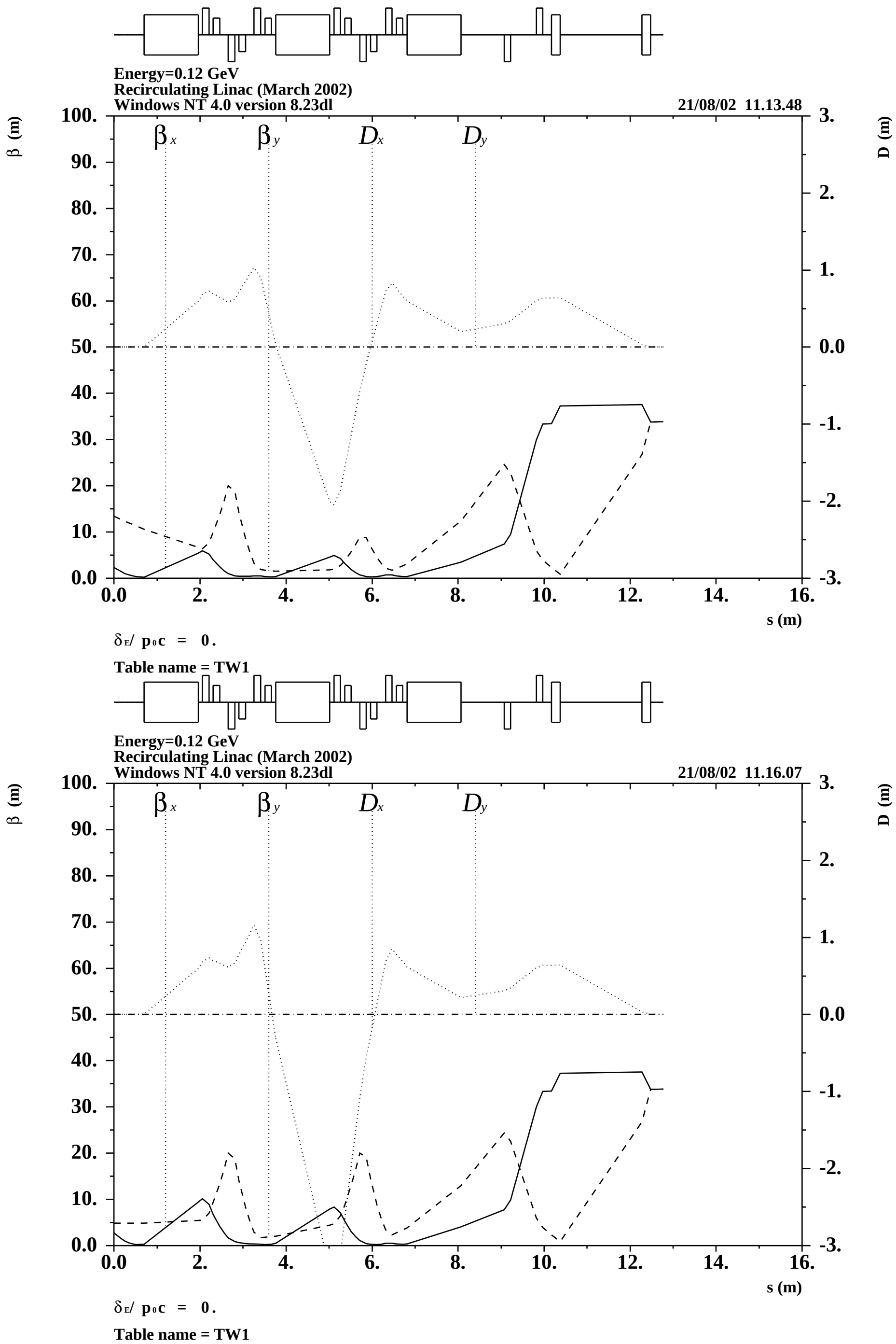


Figure 22: Lattice for the second compressor with $R_{56} = 0.55\,\mathrm{m}$ (top) and $R_{56} =$1.86 m (bottom).

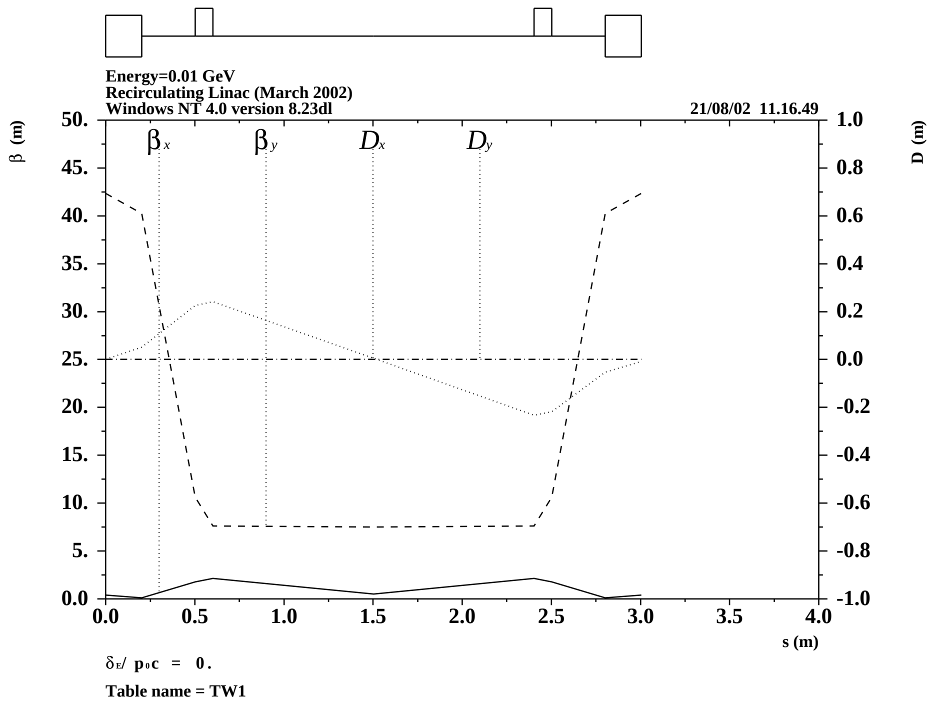


Figure 23: Dogleg used instead of the first compressor (not yet matched to the boundary conditions).

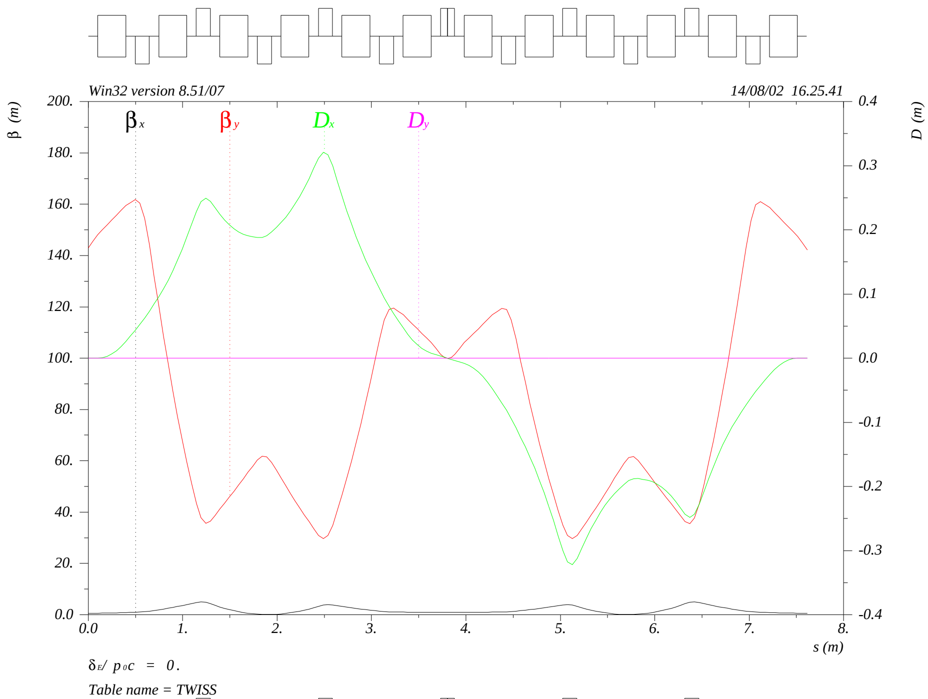
As it is not clear what is going to happen with the first compressor, Ina will instead now put the second compressor in TraFiC4 and work on a MAD to TraFiC4 converter. Sasha suggested using the output of the `tape` command in MAD as input for the converter.

4 Lattice database and CVS (I. Reichel)

So far still no one has tried the test-files in CVS. Weishi will give Ina an up-to-date version of the lattice files to put in CVS.

5 Tracking through photon production section

Massimo suggested we soon track the photon production section to study effects of offsets in quadrupoles (vertical dispersion) or phase errors of the crab cavity. In order to do that with MERLIN Andy needs the map for the crab cavity. Weishi said that he thinks it is included in Etienne's code. He will look it up and give some information to Andy so that it can be included in MERLIN. John suggested to start with an ideal kick and see what happens.



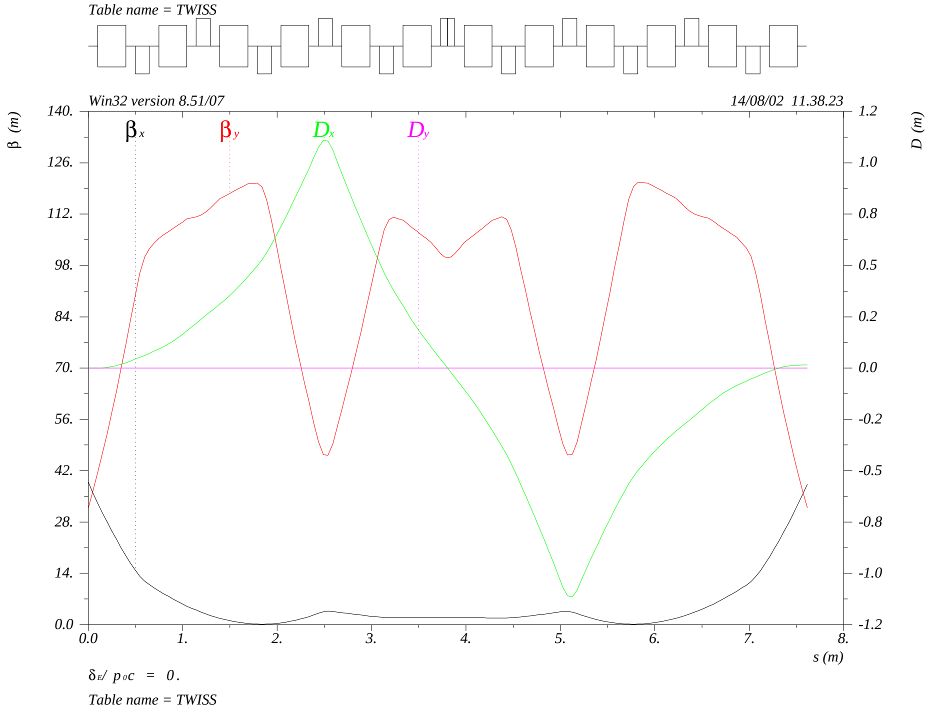


Figure 24: Lattice for the first compressor without dedicated compressor for $R_{56} = -0.26\,\mathrm{m}$ (top) and $R_{56} = -0.80\,\mathrm{m}$ (bottom).

6 Note on longitudinal dynamics with reduced R_{56}

CBP Tech. Note
August 14, 2002

Longitudinal Dynamics in the Femtosource for a Case of Reduced R56 Values

Andy Wolski and Alexander Zholents

This note describes a continuation of a study of the longitudinal dynamics in the Femtosource originated in [1].

In the original scheme we used two bunch compressors with R56 values of 0.73 m for the first bunch compressor and 0.93 m for the second bunch compressor. Attempts to produce a practical design for the first bunch compressor had demonstrated that it could be much simplier if R56 was several times smaller.

Therefore, we consider two new schemes.

In the first scheme we increased the correlated energy modulation in the first linearizer and reduced R56 in the first bunch compressor. Details of the longitudinal dynamics for this case are shown in figures 1 through 9. It is necessary to point out that in the new scheme the electron bunch propagates through the injector linac with head to tail correlated energy spread of approximately ± 130 keV.

In the second scheme we completely eliminate the first bunch compressor and do all compression from 20 ps to 2 ps in the second bunch compressor at 120 MeV. All details for this schee beginning from the end of the injector linac are shown in figures 11 through 15.

■ The first scheme

In the following plots below we show the evolution of the longitudinal phase space of the electron bunch as it progresses down the chain of the accelerators and bunch compressors. We considered only the case of a 20 ps electron bunch emerging from the photocathode gun. We begin with the window-frame distribution shown in Figure 1, where border lines are set at ± 10 ps and ± 20 keV. This is assumed to be the border lines for our longitudinal emittance coming out of the photocathode gun.

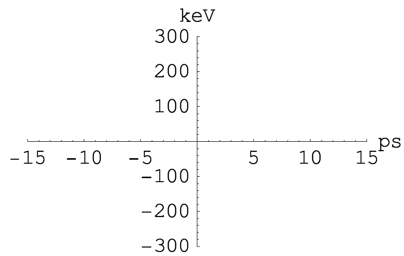


Figure 1. The initial launch of the particles.

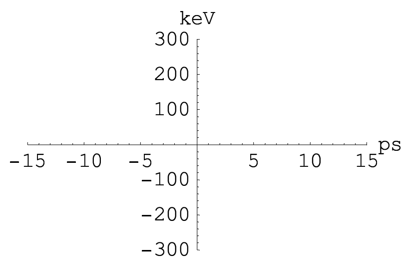


Figure 2. At the exit of the photocathode gun after acceleration to 10 MeV at the crest of the RF waveform (0° phase).

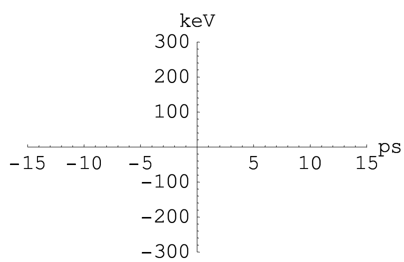


Figure 3. After the first linearizer: frequency=3.9 GHz, peak voltage=-1.4 MV, RF phase= -15°.

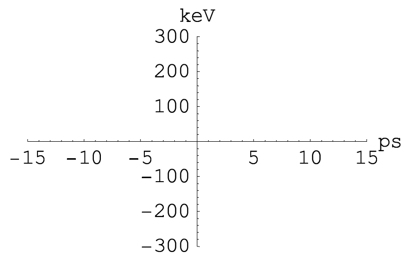


Figure 4. After the first bunch compressor. Time-of-flight matrix coefficients are: R56=0.18 m, T566=-2 m.

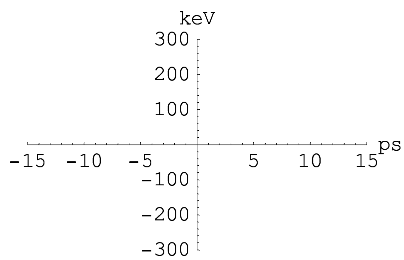


Figure 5. After the acceleration in the injector linac: peak voltage=110 MV, RF phase= -1°.

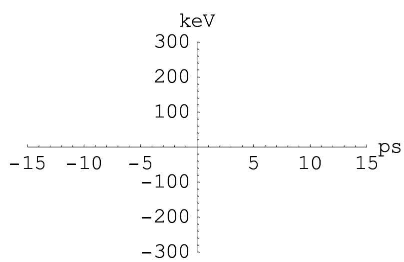


Figure 6. After the second linearizer: frequency=3.9 GHz, peak voltage=-12 MV, RF phase= -10°.

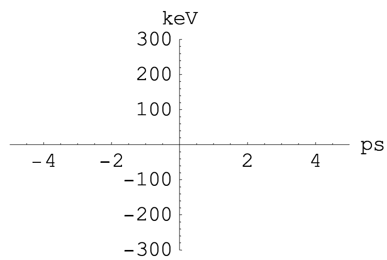


Figure 7. After the second bunch compression in the injection arc. Time-of-flight matrix coefficients are: R56=0.55 m, T566=-2 m.

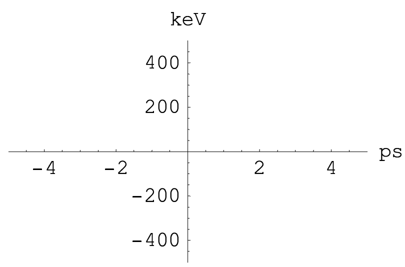


Figure 8. After the acceleration to 2.5 GeV in the reciculating linac at the crest of the RF waveform for the first three passes and at -0.4° phase at the last pass.

Next we pass the electron beam through the RF deflection cavity operated at 3.9 GHz at 90° phase from the crest. The following plot shows the tilt angle obtained by the electrons in the undulator as a function of the longitudinal off-set.

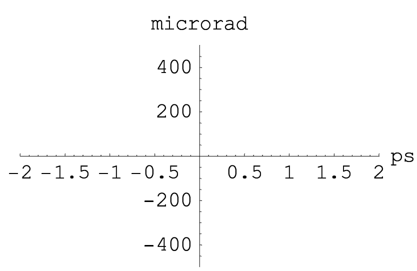


Figure 9. After the RF deflection: 3.9 GHz, 90° phase.

For comparison we show in Figure 10 the longitudinal phase space as it was in the original scheme at the end of the acceleration.

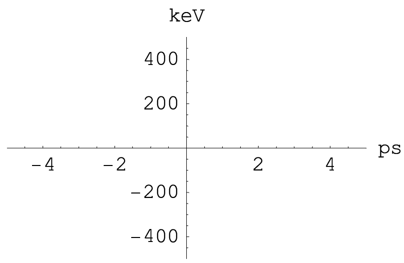


Figure 10. After the acceleration to 2.5 GeV in the reciculating linac. The original case described in [1].

■ The second scheme

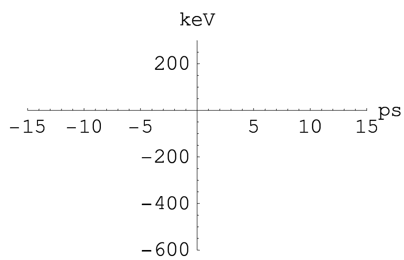


Figure 11. After the acceleration in the injector linac: peak voltage=110 MV, RF phase= 0°.

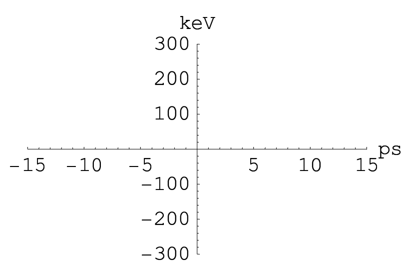


Figure 12. After the second linearizer: frequency=3.9 GHz, peak voltage=-13.5 MV, RF phase= -3°.

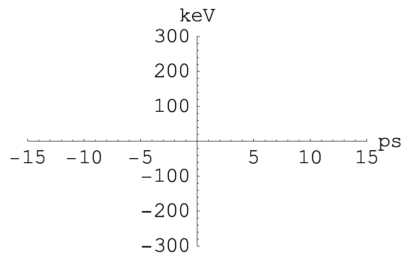


Figure 13. After the second bunch compression in the injection arc. Time-of-flight matrix coefficients are: R56=1.86 m, T566=0 m.

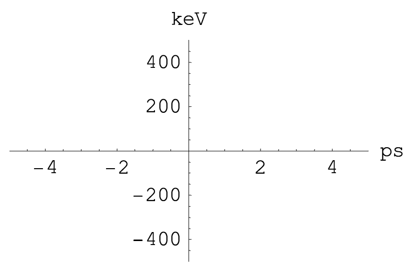


Figure 14. After the acceleration to 2.5 GeV in the reciculating linac at the crest of the RF waveform for the first three passes and at -0.1° phase at the last pass.

Next we pass the electron beam through the RF deflection cavity operated at 3.9 GHz at 90° phase from the crest. The following plot shows the tilt angle obtained by the electrons in the undulator as a function of the longitudinal off-set.

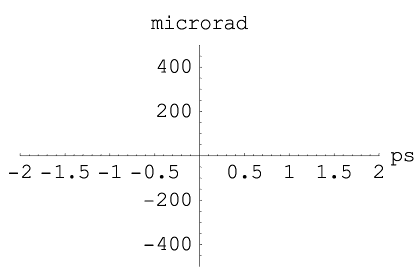


Figure 15. After the RF deflection: 3.9 GHz, 90° phase.

■ Transverse dynamics

As the next step we studied the effect of the RF focusing on the electron beam in the injector linac with correlated head to tail energy variation.

■ References

1. A. Zholents, "Longitudinal Dynamics of Electrons in the Femtosource Without Beam Current Effects", CBP Tech. Note 243, March 7, 2002.

Meeting on August 27th 2002

Minutes taker Ina Reichel

Those present J. Corlett, I. Reichel, A. Wolski, W. Wan, A. Zholents

Date August 29 2002

Distribution

J. Corlett
M. Placidi
I. Reichel
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S. de Santis
W. Wan
A. Wolski
A. Zholents

Overview of topics

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1 Relaxing R_{56} in the first compressor (A. Wolski, A. Zholents)

Sasha looked at the effect of a jitter between the laser at the source and the RF. For 1 ps jitter (which is a typical value that should not be too hard to achieve), the bunch is 10 ps long after the acceleration instead of 2 ps if two compressors are used or without the jitter. In addition the bunch has a much larger energy spread. Reducing the jitter to 0.5 ps only improves the result slightly and such a small jitter might be impossible to achieve.

Using two compressors but a relaxed R_{56} of 0.18 m in the first one gives a bunch length of about 4.0 ps after acceleration with an only somewhat increased energy spread.

For comparison, with the “nominal” compressors the bunch length is about 3.5 ps after acceleration for a 1 ps jitter.

It looks like using two compressors compensates for the jitter by some kind of cancellation mechanism. We might therefore not want to do away with the first compressor altogether.

Andy looked at the effect of using a single compressor on the transverse dynamics. In order to find any chromatic effects caused by rf focusing, he increased the energy spread significantly. Only with an energy spread of 20 % he found a small chromatic effect. Therefore chromatic effects should be negligible.

2 Update on a design of the first bunch compressor (W. Wan)

Weishi managed to reduce the number of magnets needed significantly for a lattice with an R_{56} of a little more than 0.2 m using COSY (due to differences in definitions, this corresponds to a little less than 0.2 m in MAD). All k-values are below 20. One point of worry is the β-function in the center quadrupole which is only about 0.02 m. The lattice in his current solution is sketched in Fig. 25.

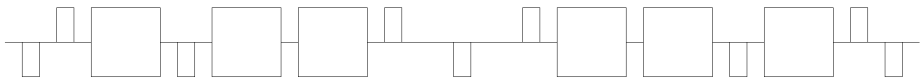

Figure 25: Schematic lattice for the first compressor (not to scale).

3 TraFiC4 (I. Reichel)

Ina has converted the second compressor into TraFiC4 format and is currently checking that the transformation is correct, i.e. β-functions etc. come out correctly.

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